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MODIS Validation, Data Merger and Other Activities Accomplished by the SIMBIOS Project: 2002-2003

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Chapter 8

Ocean Color Data Merger

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8.1 INTRODUCTION

The objective of ocean color data merger is to create a consistent series of systematic ocean color measurements from multi-instrument, multi-platform and multi-year observations based on accurate and uniform calibration and validation over the lifetime of the measurement. The most obvious benefit of data merger is improvement in spatial and temporal ocean color coverage. Single sensor daily coverage is severely limited by gaps between consecutive swaths and gaps caused by clouds, sun glint and other phenomena which hinder the extraction of ocean color (Gregg *et al.*, 1998; Gregg and Woodward, 1998). For example, merged data from three global satellite sensors, MODIS on the Terra and Aqua platforms and SeaWiFS, provide only about 40% of global ocean and inland-water coverage at 9km resolution within a single day (Section 2.6). The other critical benefit is an increase in statistical confidence in extracted bio-optical parameters. Merger algorithms can utilize sensor-varying attributes, such as spectral, spatial, temporal, and ground coverage characteristics. Merger is the ultimate tool for the creation of ocean-color climate data records.

There are many difficulties associated with ocean color data merger. Sensors have varying designs and characteristics. There are disparate instrument calibrations, data processing algorithms, and validation accuracies. The same ocean color quantities can be derived using different spectral bands and different algorithms which may cause dissimilarities in mission standard products. Discrepancies in sensor characteristics, calibrations, and data processing create relationships between data products from different instruments which may show temporal trends and dependencies on sensor observation conditions. These relationships may also be noisy, indefinite and sometimes contradictory. Data especially susceptible to noisiness are those contaminated by clouds, dust, other types of turbid atmosphere, coastal waters, and mixed pixel representations. Another type of ambiguity arises from the fact that sensors are flown over the same regions at different times of a day. Natural changes in bio-optical conditions of the global ocean occurring over these time spans are hard to establish because they are difficult to discriminate from instrument and calibration artifacts.

Detailed objectives for the creation of a consistent series of multi-instrument and multi-year ocean color observations and related ocean Climate Data Records have not yet been defined. An objective way to assess accuracy of ocean color data is through comparisons, called matchups, with *in situ* measurements (Bailey *et al.*, 2001). However, ocean color matchups against *in situ* ship-born measurements are relatively sparse. This is because of the difficulties in acquisition of *in situ* observations and uncertainties involved in comparing *in situ* measurements against satellite-derived data. Over the sensors' lifetime, there have been 250 chlorophyll-a concentration matchup points, strictly screened for quality, for SeaWiFS and 34 for MODIS-Terra (http://seabass.gsfc.nasa.gov/matchup_results.html). Therefore, matchups with *in situ* observations are mostly used for intermittent validation of sensor data in concert with spatial and temporal data consistency analyses. The other approach to validation is matchup of ocean color data between sensors (Chapter 2; Kilpatrick *et al.*, 2001). This method assesses discrepancies between sensors over global to local zones and daily to seasonal time scales. Such assessments are vital for the data merger because they enable extraction of disparate trends and trend dependencies in data from different instruments.

There have been a number of methods developed to merge ocean color data. These methods include averaging and weighted averaging of data within the sensor overlapping coverage (Section 4.1). Blending algorithms have been applied which fit a function over shape-of-the-field defining data from one sensor given an internal boundary condition delimited by data from the other sensor or *in situ* observations (Gregg and Conkright, 2001). A semi-analytical optical algorithm has been developed which uses combined nLw retrievals within overlapping coverage at different sensor-specific wavelengths to calculate chlorophyll concentrations, combined detrital particulate and dissolved absorption coefficients, and particulate backscattering coefficients (Maritorena *et al.*, 2002; Maritorena *et al.*, 2000).

The major data merger effort undertaken by the SIMBIOS Project Office focused on integrating ocean color data from global sensors at a daily temporal resolution. MODIS-Terra and SeaWiFS data were used to study methodologies to create a consistent series of long-term observations from sensors of different design, characterization, processing algorithms, and calibrations. The information derived from MODIS-Terra and SeaWiFS comparisons, described in Chapter 2, was used to derive an ocean color sensor cross-calibration strategy to eliminate pronounced data temporal discrepancies between the sensors and MODIS data artifacts. Statistical objective analysis was investigated to spatially and temporally interpolate MODIS-Terra (cross-calibrated with SeaWiFS) and SeaWiFS data onto daily global ocean color maps using individual sensor accuracies and producing error bars for each data point on the map. Additional research was performed to support local-area data merger applications, for instance in coastal zones. These applications utilized ocean color data of different spatial resolutions and *in situ* measurements. The multiresolution merger focused on enhancement of oceanic features in lower resolution imagery using higher resolution data.